

DEEP MEDIAN STERNOTOMY WOUND INFECTION AFTER OPEN HEART SURGERY

By

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Deep median sternotomy wound infection is a significant source of morbidity and mortality after open cardiac surgery. Between January 1994 and May 2001, 600 open-heart procedures using median sternotomy and cardiopulmonary bypass were performed in Mansoura Cardiothoracic Surgery Department. A total of 28 patients (4.6%) with deep sternotomy wound infection were identified.

Most of these infections were associated with a number of risk factors such as prolonged preoperative hospital stay (75% $P < 0.001$), obesity (68% $P < 0.05$), diabetes mellitus (54% $P < 1.001$), prolonged operative time (71% $P < 0.001$), prolonged cardiopulmonary bypass (68%, $P < 0.05$), prolonged ventilation, (75% $P < 0.05$) and reexploration for control of bleeding or tamponade (32% $P < 0.001$). Most of these infections were caused by staphylococcus aureus (46.4%). To study the risk factors for mediastinitis, the patients were divided into 2 groups, group I (Mediastinitis group, 28 patients) and group II (Control group, 28 consecutive mediastinitis free patients).

For the evaluation of the effective surgical procedure in the mediastinitis group, infected patients were further subdivided into 2 subgroups, subgroup A (open technique) and subgroup B (closed technique).

In the open technique we open the wound and dress it three times daily for about 2 weeks until the wound becomes clean with healthy granulation tissue then reclosure of the sternum after debridement using Bonecheck technique. In the closed technique we close the sternum using Bonecheck technique after debridement with closed irrigation system using diluted betadine solution. The overall mortality in our mediastinitis group of patients was 25%. It was more in the open technique (44.4%) than in the closed technique (15.8%), ($P < 0.001$ Hs)

We conclude that, careful preoperative preparation, rapid surgical technique with careful haemostasis and strong perioperative antibiotics are required to reduce the incidence of mediastinitis. Early treatment under coverage of strong antibiotics debridement and closed irrigation system with proper reclosure of the sternum by Bonecheck technique improve the sternal stability and reduce the morbidity and mortality than the open technique.

Keywords: Median sternotomy Wound infection.

INTRODUCTION

Median sternotomy is the most common incision for cardiac surgery. Deep sternotomy wound infection, although rare, is a major cause of morbidity and mortality following cardiac surgery. ⁽¹⁾ The reported incidence of such infection ranges from 0.3% to 5% with an associated

mortality rate ranging between 7% and 70%. ⁽²⁾ Timely diagnosis of deep sternotomy wound infection requires a high index of suspicion. Warning signs may include fever, leukocytosis, wound leakage, local tenderness, signs of systemic septicemia or toxic effectes and sternal instability.⁽³⁾ Deep sternal infections are most commonly caused by staphylococcus aureus and coagulase negative

stapyllococci. A variety of gram-negative bacilli including klebsiella pneumonia, pseudomonas aeruginosa as well as candida have all been reported. ⁽⁴⁾ Management of an infected median sternotomy incision is a subject of controversy. ⁽⁵⁾ Several approaches have been described to treat this complication. These include dressing changes, debridement and closure by secondary intention; or debridement, sternal reclosure and closed irrigation, or debridement, open dressing changes and delayed closure with muscle flaps ⁽⁶⁾. However, major plastic procedures to fill the gap of the dehiscence sternum mean long hospitalization, complex operation, and chest cage instability until it is completed. Also any future cardiac reoperation is difficult or impossible ⁽⁷⁾.

The aim of this study is to assess the experience of our department in dealing with deep sternal wound infection following open cardiac surgery and how to reduce the incidence and solve the problem by the best method of management.

PATIENTS AND METHODS

Between January 1994 and May 2001, 600 patients underwent median sternotomy for open-heart surgery in the Cardiothoracic Surgery Department, Mansoura University Hospitals. The patients included in this study are those having deep sternal infection and mediastinitis with partial or complete sternal dehiscence following sternotomy for open-heart surgery. Patients with superficial subcutaneous infection and stable sternum are excluded from this study. Of these 600 patients 28 cases (4.6%) suffered from mediastinitis.

These patients included mitral valve replacement (MVR) and tricuspid repair (6 patients), MVR (5 patients), double valve replacement (DVR) and tricuspid repair (4 patients), aortic valve replacement AVR (4 patients), DVR (3 patients), VSD repair (3 patients), mitral valve re-replacement (2 patients), and aortic root replacement (1 patient). Table (1) shows this distribution.

Risk factors:

The following factors were considered as risk factors for mediastinitis and were viewed for the affected patients: age, sex, presence of diabetes mellitus; obesity, preoperative New York Heart Association (NYHA) class, previous sternotomy, bypass time, aortic cross clamp time, preoperative hospital stay, operation time, ventilation time and reexploration for bleeding. Table (2) shows risk factors for mediastinitis.

General management of patients undergoing open heart surgery:-

Prophylactic antibiotics were given 1 hour before with the induction of anesthesia and continued for 5 to 7 days

postoperatively. Parenteral third generation cephalosporins as claforan, fortum, cefobid were used in all patients with or without other antibiotics.

In the morning of the operative day, all patients were shaved for chest, axillary and pubic hairs.

The operative field was scrubbed and painted with povidone-iodine solution, and adhesive draps were applied to the surface of the operative field prior to skin incision.

The operative approach in all patients was through median sternotomy with cardiopulmonary bypass and moderate systemic hypothermia (28°-30°C). Also, local hypothermia and blood cardioplegia were used in most of our patients, with crystalloid cardioplegia in some patients.

Bubble or membrane oxygenators and roller pump were used for extracorporeal circulation. Sternal closure was done with 6 to 8 stainless steel wires no. 3 to 5. Two were placed through the body of the manubrium, and the others were used to encircle the body of the sternum at different interspaces. The overlying soft tissues were closed in two layers, with absorbable sutures.

Diagnosis of mediastinitis:

The presence of signs of infection such as fever, pain, leukocytosis, oedema of the wound, erythema, discharging wound and sternal instability give a high index of suspicion with possibility of deep sternal wound infection. Chest radiography and echocardiography confirm the suspicion of mediastinal collection and infection with infrequent use of CT scanning of the chest in some cases.

In order to evaluate the subject of mediastinitis we divided the patients into 2 groups, group 1 and group 2. Group I represents the mediastinitis group (28 patients) and group II represents the control group (28 patients).

Group I (28 patients) was further subdivided into subgroup A (9 patients) and represent the patients treated by the open technique and subgroup B (19 patients) represents the patients treated by the closed technique.

Once the diagnosis of mediastinitis has been established, all of our mediastinitis patients (28 patients) underwent surgical procedure by one of the following 2 methods:

1- Open technique (opening of the wound with daily dressing then debridement and secondary closure were done) (subgroup A). This technique was used for 9 patients where the wound was reopened with cutting of the stainless steel wires then dressing 3 times daily until cleaning of the wound. This dressing took about 2 weeks, then the patients were taken to the operative room for

debridement and reclosure of the sternum by secondary sutures using Robisch technique. This technique was done by heavy thread of wires which were taken parasternally around the cartilages in and out and out and in until it reaches the lowermost point then turns up again in the same manoeuvre. Then perpendicular wiring sutures were used to reclose the sternum with mediastinal tubes left to drain the mediastinum.

2- Closed technique (debridement and closure of the sternum on a closed wound irrigation system) (subgroup B). This technique was used in 19 patients where reexploration of the mediastinum and local debridement of affected areas were done. Then the wound was irrigated with one to two liters of warm saline and (povidone iodine (0.5%). Then two tubes for subsequent irrigation and drainage of the retrosternal space were inserted one 14-16 FG for inflow in the upper part of the wound and the other one 30-32 FG in the lower part, lastly the sternum was reclosed using bonecheck technique as in the open technique.

Post operatively, the mediastinum was irrigated with 10% povidone iodine solution diluted in normal saline 1:20 (0.5%) at a rate of 2-5 liters per day for about 7-10 days then irrigation was stopped and the tubes were removed 2 days later.

One case treated by this technique needed reexploration for severe infection and was treated by omental flap with the help of a plastic surgeon.

Appropriate systemic antibiotic therapy supplemented both methods of treatment.

RESULTS

Table (1) shows the different operative procedures which were done for the mediastinitis group.

Table (2) shows the different risk factors studied in both group I (mediastinitis group 28 patients) and group II (control group 28 patients) with the following results: (using the Z test and chi-square test):

- (A) Age, diabetes mellitus, NYHA class, hospital stay, operative time, aortic cross clamp time and reexploration for bleeding were high risk factors $P < 0.001$ (HS).
- (B) Bypass time and ventilation time were proved to be risk factors $P < 0.05$ (significant).
- (C) Sex, previous sternotomy and obesity were not proved as risk factors (NS) P value (> 0.05) .

Table (3) shows the type of organisms causing infection:

- Staphylococcus aureus represents (46.4%) of all infections, pseudomonas represents (21.4%), while klebsiella represents (17.9%) and the culture was negative in about (14.3%) of all cases.

Table (4) shows the operative procedures done and the associated mortality rates of the closed technique and the open technique. On comparing the mortalities among subgroup A and B we found that higher mortality rate among the patients treated with the open technique (44.4%) was found in comparison with the patients treated by the closed technique (15.8%) $P < 0.001$ (HS), while the total mortality rate was 25%.

Table (1): Operative procedures in patients with mediastinitis

<i>Operative procedure</i>	<i>No of patients</i>	<i>Percent %</i>
MVR+tricuspid repair	6	21.4%
MVR	5	17.9%
DVR+ tricuspid repair	4	14.3%
AVR	4	14.3%
DVR	3	10.7%
VSD repair	3	10.7%
MV rereplacement	2	7.1%
Aortic root replacement	1	3.6%
Total	28	100%

Table (2): Risk factors for mediastinitis

<i>Risk factor</i>	<i>Mediastinitis group 28 cases</i>	<i>Control group 28 cases</i>	<i>P value</i>
Age :			
<40 years	11	16	<0.001
≥40	17	12	
Sex:			
Male	16	11	>0.05
Female	12	17	
NYHA class			
<3	10	18	<0.001
≥3	18	10	
Diabetes mellitus			
Yes	15	11	<0.001
No	13	17	
Obesity			
Yes	19	17	>0.05
No	9	11	
Previous sternotomy			
Yes	2	1	>0.05
No	26	27	
Hospital stay			
< 20 day	7	6	<0.001
≥20 days	21	22	
Operative time			
<4 hours	8	20	<0.001
≥4 hours	20	8	
Bypass time			
<100 min	9	18	<0.05
≥100 min	19	10	
Aortic cross clamp time			
<60 min	10	16	<0.001
≥60 min	18	12	
Reexploration for bleeding			
Yes	9	2	<0.001
No	19	26	
Ventilation time			
<6h	7	21	<0.05
≥6h	21	7	

Table (3): Types of organisms causing mediastinitis

<i>Organism</i>	<i>No of patients</i>	<i>Percent %</i>
Staphylococcus aureus	13	46.4%
Pseudomonas	6	21.4%
Klebsiella	5	17.9%
Negative cultures	4	14.3%
Total	28	100%

Table (4): Comparison between closed and open techniques

<i>Operative procedure</i>	<i>No.</i>	<i>Closed technique</i>	<i>Mortality</i>	<i>%</i>	<i>Open technique</i>	<i>Mortality</i>	<i>%</i>
MRV+Tricuspid repair	6	4	1	25	2	-	0
MVR	5	4	-	0	1	1	100
DVR+tricuspid repair	4	2	1	50	2	-	0
AVR	4	3	1	33.3	1	1	100
DVR	3	2	-	0	1	1	100
VSD	3	3	-	0	-	-	0
MV rereplacement	2	1	-	0	1	-	0
Aortic root replacement	1	-	-	0	1	1	100
Total	28	19	3	15.8	9	4	44.4

The total mortality in the closed method was 3 out of 19 patients (15.8%) and the total mortality in the open method was 4 out of 9 patients (44.4%). The total mortality rate was 7 out of 28 patients (25%).

DISCUSSION

Median sternotomy is now one of the most common employed incisions in cardiac surgery and accepted almost universally as the preferred access to the heart for coronary artery bypass grafting and valve replacement⁽⁸⁾. However, since its introduction to the common clinical practice and popularisations in 1953 by Julion et al.,⁽⁹⁾ this incision has been plagued by the complications of acute mediastinitis, mechanical instability of the sternum and complete dehiscence⁽¹⁰⁾. While the overall risk of open heart surgery currently are low, wound infection remains one of the potentially serious complications⁽¹¹⁾. The reported incidence of such infection ranges from 0.3 % to 5%⁽¹²⁾ or even 6%⁽¹³⁾ with an associated mortality rate ranging between 7% and 70%⁽¹⁴⁾. With early effective treatment this may be reduced to below 10%⁽¹⁵⁾. Several studies have examined the occurrence and possible risk factors for development of serious sternotomy infections. Underlying conditions such as diabetes mellitus, obesity, chronic lung disease, smoking, length of preoperative hospitalization, cardiopulmonary bypass time, use of internal mammary artery grafts, reexploration for bleeding, repeated operation, prolonged ventilation and hypoperfusion have been associated with the development of serious sternotomy infection^(16,17,18).

In our study, the high incidence of mediastinitis (4.6%) as compared to others; 2.3%⁽¹⁹⁾ or 2%⁽²⁰⁾ may be due to presence of many predisposing risk factors such as diabetes mellitus, high incidence of redo surgery, older age group, prolonged operative time, cardiopulmonary bypass time, ventilation time and preoperative low cardiac output which was proved as highly significant risk factor.

Our results could be explained on the basis of that for preoperative factors, age and diabetes mellitus, increased infection due to compromised immunity.

Most commonly, mediastinitis is seen between 4 and 30 days postoperatively and usually within two weeks of the original procedure^(2, 21, 22). In our series, all cases of mediastinitis appeared between 3 and 10 days postoperatively except one case in the first postoperative day when reopened to replace the aortic root and Bentall operation was done for acute aortic dissection.

Wound discharge is the most common presentation and occurs in 70% to 90% of cases, other local symptoms include wound pain, tenderness and sternal instability^(5, 23). Fever and leukocytosis in the absence of local symptoms or signs may be the only presenting clinical features in a

smaller percentage of patients (5% and 24% respectively). In our study wound discharge was present in 21 patients (75%) with sternal tenderness and instability, while the other 7 patients (25%) with clean wound presented after removal of mediastinal drains by fever, leukocytosis and sternal instability and chest X-ray and echocardiography confirmed mediastinal collection.

The most common pathogen causing postoperative mediastinal infection remains staphylococcus aureus. Gram negative organisms, primarily klebsiella, proteus, pseudomonas and enterobacter, are less common etiological agents in the development of mediastinitis^(2,19). In our study, staphylococcus aureus was responsible for 46.4% of infections, followed by pseudomonas (21.4%), klebsiella (17.9%), and the cultures were negative for organisms in (14.3%). This is similar to other Egyptian studies where the percentage were staphylococcus aureus (43.4%), klebsiella (20%), pseudomonas (10.9%) and also negative culture in about (7.8%)⁽²⁰⁾. This result could be explained on the basis of the hot climate in our country.

Prophylactic antibiotic administration during cardiopulmonary bypass is now accepted as a standard practice^(5, 25). Patients undergoing open heart operations routinely receive perioperative prophylaxis with cefuroxime 1.5 gm three times daily. Prophylactic antibiotics were given in the operating room by the anaesthesiologist immediately before the induction of general anaesthesia and their administration were continued for 48 hours postoperatively⁽¹⁾. All of our patients also routinely received prophylactic antibiotics in the form of third generation cephalosporines and despite careful preoperative preparation, good hemostasis and good surgical technique, deep sternal wound infection occurred.

Several approaches have been used to treat this major complication⁽¹⁵⁾. The technique of debridement and sternal reclosure followed by mediastinal antibiotic irrigation has been used since Shuwilker and Mandelbaum report of two cases in 1963⁽²⁵⁾.

We have used this closed technique of debridement, primary sternal closure and irrigation in 19 patients with sternal infection and mediastinitis. Povidone iodine 10% diluted in normal saline 1:20 (0.5%) was the irrigation solution rather than antibiotic as described by Grosi et al.,⁽⁴⁾ because some reports indicated that antibiotic irrigation may be followed by fungal mediastinitis⁽²⁶⁾ and unusually high morbidity and mortality⁽²⁷⁾.

For pediatric age group, this method may be used with alteration in both volume and concentration of povidone iodine solution with careful monitoring of serum iodine to avoid iodine toxicity⁽²⁸⁾. A diluted solution was used in our pediatric age group, so no iodine toxicity has been observed.

Satisfactory results were obtained using this technique, however 3 patients required reexploration for persistent infection (failure rate 3/19, i.e. 15.8%). Recurrence probably reflects inadequate debridement due to either inability to recognize the diseased tissue or to surgical caution regarding the degree of soft tissue defect that would result.

Also, when operation is postponed and the infection precedes, a different pathological problem evolves, sternal osteomyelitis or infection of the wire around the sternum and adjacent cartilage occurs. Once osteomyelitis is established, closed drainage is far less effective and probably failed even with radical debridement. Successful treatment of sternal wound infection with muscle flap was described by Jurkiewicz and associates (24) and leads to dramatic increase in use of muscle or omental flap (30). Only one case in our series was treated with omental flap which was used after failure of closed technique and this patient was reexplored for severe infection and omental flap was used with the help of a plastic surgeon but this patient died later from multiorgan system failure.

Open packing technique needs frequent dressing changes with antibiotic soaked gauze in combination with systemic antibiotics which places substantial physical and psychological stress on the patient. In addition, reoperation is necessary in a quarter of the patients for persistent infection or failure of the wound to adequately close. The mortality rate is high (22%) with hospital stay averaging 49 days(4). Open technique was used in our study in 9 patients in the first era of open heart surgery in our department. In this stage, when mediastinitis occurred, these patients were reexplored, then twice to thrice dressing daily were done for about 2-4 weeks until cleaning of the wound, then these patients were taken to the operating room for reclosure of the wound. From our result in this technique, we showed that there is physical and psychological stress on these patients with increased cost due to frequent daily dressing and long hospital stay (average 2 months) with systemic antibiotics. Also this technique had high mortality rate; 4 out of 9 patients (44.4%).

So, the closed method became the method of management of these patients with lower mortality rate 3 out of 9 patients (15.8%).

CONCLUSION

Although mediastinitis remains a life threatening complication of median sternotomy incision, the prevention of this serious infection depends on a combination of the following:

1- Proper preoperative preparation of the patient such as adequate skin preparation, reduction of preoperative hospital stay, control of diabetes mellitus and obesity.

2- Prophylactic antibiotics should be routinely used and continued until surgical wounds become sealed and all catheters and drains are removed.

3- Meticulous surgical techniques, accurate midline sternal incision, short operative time, ischaemic time and perfusion time, meticulous haemostasis and proper sternal approximation are the most important factors for prevention of sternal dehiscence and mediastinitis.

4- Special reinforced method of sternal closure as Robische technique should be applied in the presence of risk factors of mediastinitis as diabetes mellitus, obesity, reoperation, sternal dehiscence, anticipated postoperative low cardiac output, and anticipated prolonged respiratory assistance.

5- Finally, early diagnosis before spread of infection to the bone is important, then adequate and radical debridement of the sternum and soft tissues to the bleeding new point is mandatory with closure of the sternum by Bonechecke technique and closed irrigation system.

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